AVSS 2011 demo session:
Construction Site Monitoring from Highly-Overlapping MAV images

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Abstract

We present a concept for automatic construction site monitoring by taking into account 4D information (3D over time), that is acquired from highly-overlapping digital aerial images. On the one hand today’s maturity of flying micro aerial vehicles (MAVs) enables a low-cost and an efficient image acquisition of high-quality data that maps construction sites entirely from many varying viewpoints. On the other hand, due to low-noise sensors and high redundancy in the image data, recent developments in 3D reconstruction workflows have benefited the automatic computation of accurate and dense 3D scene information. Having both an inexpensive high-quality image acquisition and an efficient 3D analysis workflow enables monitoring, documentation and visualization of observed sites over time with short intervals. Relating acquired 4D site observations, composed of color, texture, geometry over time, largely supports automated methods toward full scene understanding, the acquisition of both the change and the construction site’s progress.

1. Overview

To get toward highly-automated construction site monitoring and documentation from digital imagery there is a need to acquire every visible spot on ground with an inexpensive and flexible sensor platform. In particular, MAVs allow us the acquisition of highly-redundant site observations from different viewpoints. Having scene observations from different views enables the computation of accurate 3D scene geometry. Figure 1 shows some aerial shots of a construction site, which are taken at three different days from two similar viewpoints. Although the images are spatially and temporally unordered the progress made at the site is visible clearly.

In our case the digital aerial images and their initial GPS positions are collected with a consumer camera equipped on an octo-rotor flying vehicle. This setup enables a flexible and large-scale acquisition of series of single shots or video streams by user-control as well as by an autonomous flight management. Based on the collected data, the 3D reconstruction workflow, consisting of highly-parallelized computation steps, yields dense 3D scene geometry for individual time stamps, e.g., on a daily or a weekly basis.

A further step considers the obtained 4D scene information and supports the detection of changes from deviant geometry considerations as well as from variation in the visual appearance. Having knowledge about scene changes allows us to document and understand processes, but also to high-

1Asctec Falcon 8/Panasonic DMC-LX3
light and visualize the progress made at the construction site. In particular, modern techniques in augmented reality provide sophisticated methods to overlay spatially referenced CAD or 3D sketches on a view of the real world or to place human in the loop to handle user-queries and generate specific visualizations.

2. Workflow

Our proposed workflow consists of dense 3D scene reconstruction, the alignment of time-dependent 3D models and a stage focusing on the detection and understanding of change.

As a first step the digital images are matched efficiently and sparse scene geometry and camera poses are estimated the approach described in [2, 3]. This 3D reconstruction workflow is able to automatically process sets of images acquired with the MAV platform. Since representative feature descriptors are extracted and available for each 3D point, the structure from motion results (i.e. the sparse 3D models as well as the camera poses) can be aligned within a common world coordinate system by using known correspondences. In addition, the availability of the descriptors benefits an efficient integration of additional camera sources like images acquired from the ground or mounted web-cams.

By introducing synthetic viewpoints, e.g., a nadir sight or any oblique view onto the site, allows us to automatically detect and monitor changes and variations over time. Based on an initial semantic interpretation, like the knowledge about built volumes and ground as well as the locations of excavators, cranes and other non-stationary objects we are able to understand the process made at the construction site. Moreover, the holistic scene understanding makes possible interactive and query-dependent visualizations. We therefore apply augmented reality techniques like image-based localization and tracking on mobile devices, but we also use X-ray visualization methods, which enable a transparent view through real objects or make occluded regions visible [5, 6].

3. Presentation Preview

In our presentation we show various 4D models of observed construction sites. In particular, we focus on the automatic detection and visualization of relevant change and how to establish suitable interfaces to existing 3D applications in the field of building information models (BIMs). In addition, we present results on augmented reality visualizations.

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References